

NEOTUNGA EULOIDEA GEN. N., SP. N.
(SIPHONAPTERA : PULICIDAE)

By F. G. A. M. SMIT

SYNOPSIS

A new species of flea, parasitic on pangolins, and showing both pulcid and tungid characters, is described.

THE pangolin *Manis temmincki* Smuts is widespread in southern and eastern Africa, but never common nor very easy to collect. In 1956, a female pangolin, captured in the Sinoia District of Southern Rhodesia, was brought to the University College of Rhodesia and Nyasaland at Salisbury, where it was kept alive for two years. After it had died, in August 1958, Dr. J. S. Weir of the Zoology Department examined the body and found a number of jigger-like fleas embedded in the skin of the underside of the animal. An appeal made by Dr. Weir to some members of the staff of the National Museum of Southern Rhodesia, at Bulawayo, for more fleas and other parasites of pangolins resulted in six additional specimens of the same flea collected by Mr. M. P. Stuart Irwin from a pangolin caught near Lonely Mine, Southern Rhodesia, in June 1960. Dr. Weir sent three of these specimens to Dr. L. H. Finlayson of the Department of Zoology, University of Birmingham, with the request to have this material identified. I am deeply indebted to Dr. Finlayson for having sent the specimens to the British Museum (Natural History), for these fleas have proved to be the most interesting and instructive new species which has ever come my way. According to recent classifications this flea belongs to one Family (or Subfamily) on the structure of head and thorax, and to another Family (or Subfamily) on most of the characteristics of the abdomen.

I am most grateful to the gentlemen mentioned above for having made an important discovery and for the generosity with which they have placed all specimens at my disposal.

Meanwhile Dr. Weir collected twelve more females from a pangolin captured near Que Que, also in Southern Rhodesia. All the fleas so far collected are females. The males, which are very likely minute and free-living, should be searched for in the nesting places of pangolins, which might be difficult to detect. I sincerely hope that Dr. Weir and Mr. Stuart Irwin will eventually discover the male specimens which they so kindly offered to search for, as the structure of the genitalia of the male would give valuable supporting evidence of the origin of sand-fleas.

NEOTUNGA gen. n.

Chaetotaxy reduced. Frontal margin of head angulate, with an upward pointing tubercle. Eye developed, sometimes with an internal sinus. First two segments of antennal clava lamellate, the other segments fused. Epipharynx with a number of minute tubercles along anterior margin ;

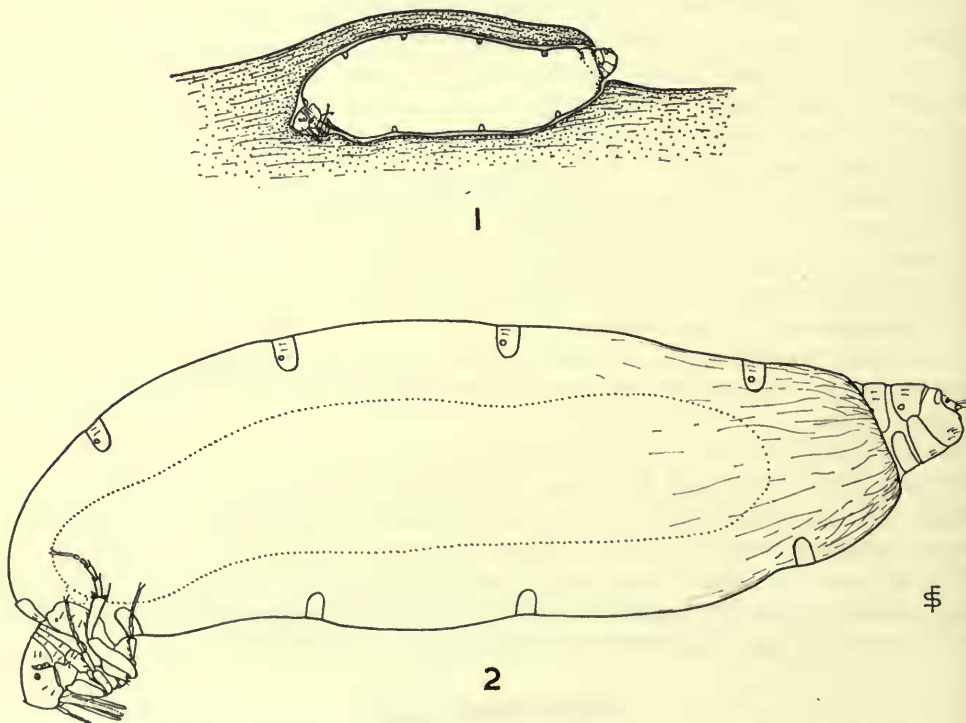
laciniae strongly serrated; labial palp membranous. Maxillary stipes of median size, extending below genal margin. Thorax dorsally narrower than length of tergum I. Prosternosome with epimeral flange ventrally drawn out into a triangular lobe; mesosternal furca long and narrow. Metasternal ridge with a semi-distinct forward branch. Vincula absent. Oblique hyaline break of mid coxa complete. Hind coxa with a patch of spiniforms on inner side and with a ventro-anterior spur. *Female*: spiracular fossa of posterior terga larger than those of anterior terga; two leucodiscs above spiracular fossae. Anterior setae absent. No seta above the large spiracular fossa of tergum VIII. Genital setae of tergum VIII well developed. Sternum IX membranous. Sensillum not divided dorsally, with eight trichobothria each side. Anal tergum not much reduced, with a short but stout stylet. Spermatheca rather large, with a dorsal orifice; without a line of demarcation between bulga and hilla.

Type of genus: *Neotunga euloidea* sp. n.

***Neotunga euloidea* sp. n.**

(Text-figs. 1-3, 6-12, 15, 16. Pl. 1)

Holotype female and 10 female paratypes from SOUTHERN RHODESIA, Sinoia District: on *Manis temmincki* (adult ♀), viii. 1958 (J. S. Weir); 6 female paratypes from SOUTHERN RHODESIA, Lonely Mine, 19° 30' S., 28° 42' E.: on *Manis temmincki*,



FIGS. 1-2. *Neotunga euloidea* sp. nov. 1. Embedded female under the skin of *Manis temmincki*. 2. Expanded female removed from under the skin (the midgut is shown in dotted outline).

30.vi.1960, (*M. P. Stuart Irwin*); 12 female paratypes from SOUTHERN RHODESIA, 15 miles S.E. of Que Que: on *Manis temmincki* (adult ♀), 21.x.1960 (*J. S. Weir*).

Holotype and a number of paratypes in the British Museum (Tring), other paratypes in the collection of Lt.-Col. R. Traub, Washington, D.C.; the Canadian National Collection of Insects, Ottawa; the University College of Rhodesia and Nyasaland, Salisbury; the National Museum of Rhodesia and Nyasaland, Bulawayo; the Antiplague Research Institute, Stavropol and the Schweizerisches Tropeninstitut, Basel.

As no other species of *Neotunga* are known, the generic characters may be taken as diagnostic for the species.

Head (Text-fig. 3). Frons angulate, with a distinct vertical tubercle; dorsal margin of head about twice as long as the frontal margin below the tubercle. Wall of cranium fairly thick. Ventral margin of head with a broad rounded genal lobe. Preoral tuber not excessively large. Ocular seta very small, placed below level of eye; genal seta slightly larger than the ocular one. Occipital region with two setae. A number of microsetae, most of which are pointing upwards, on frontal and dorso-occipital regions. Eye well developed, subglobular, but not very large, with or without an internal sinus. Antennal scape with one minute ventroposterior seta; pedicel with about half a dozen longish setae which do not reach to the apex of the clava; first two segments of clava lamellate, the other segments completely fused; on outer surface of clava only a few minute setae. Anterior longitudinal half of antennal fossa covered by the flange-like extension of the postocular genal margin which thus covers the anterior half of the antenna. No setae bordering the antennal fossa dorso-posteriorly. One leucodisc, representing a placoid, on the preantennal region of head, three on the postantennal region. First segment of maxillary palp nearly twice as long as the second segment, third segment as long as second, fourth segment a little longer than the third; the palp reaches nearly to the level of the apex of the fore coxa: stipes short, but still protruding well below the genal margin. Epipharynx fairly broad, with small projections over most of the length of the anterior margin; lacinia very broad and with strong anterior and posterior serrations; the two-segmented labial palp is membranous—these three mouth-parts are about $1\frac{1}{2}$ times as long as the fore coxa.

Thorax (Text-fig. 3). Thorax dorsally only about half as long as tergum I; pronotum and mesonotum dorsally of the same length, metanotum nearly twice the length of either of the first two nota; there is no fusion between the nota. Pronotum with four slender setae each side, mesonotum with two setae and metanotum with one subdorsal seta each side. Flange of prosteronosome with a triangular lobe pointing backward, mesosternosome with two setae. Metasternum without setae, metepimeron with a row of three slender setae. Pleural arch-joint of metathorax and the associated metanotal and pleural ridge well developed.

Legs (Text-figs. 3, 6-8). Setae on outer surface of fore coxa not very numerous and most of them are small. Outer surface of mid coxa with an oblique hyaline break and a relatively small number of very short setae at and near the anterior margin, on inner side a few similar setae. Hind coxa with short setae scattered over the outer surface; on the inner surface, apart from some thin setae, an oblique dense patch of short spiniforms. Ventro-anterior angle of hind coxa drawn out into a pointed triangular tooth. Outer internal rod and inner internal ridge of hind coxa not strongly developed. Femora with a number of small setae along the dorsal margin; on inner surface with one lateral seta on proximal part of fore femur with two such setae on mid and hind femur; all femora with one preapical lateral seta on inner surface. Tibiae with two notches in posterior margin each of which bearing two short setae the outer one of which is the stoutest; without lateral setae; ventro-anterior angle of tibiae with two setae, ventro-posterior angle with two setae on fore and mid tibia, three on hind tibia.

Tarsi as shown in Text-figs. 6-8; note the reduced chaetotaxy, especially of the fifth tarsal segments which only bear one pair of thin sub-basal plantar setae, one pair of preapical plantar setae and the usual pair of preapical lateral setae; claws basally with only a slight swelling.

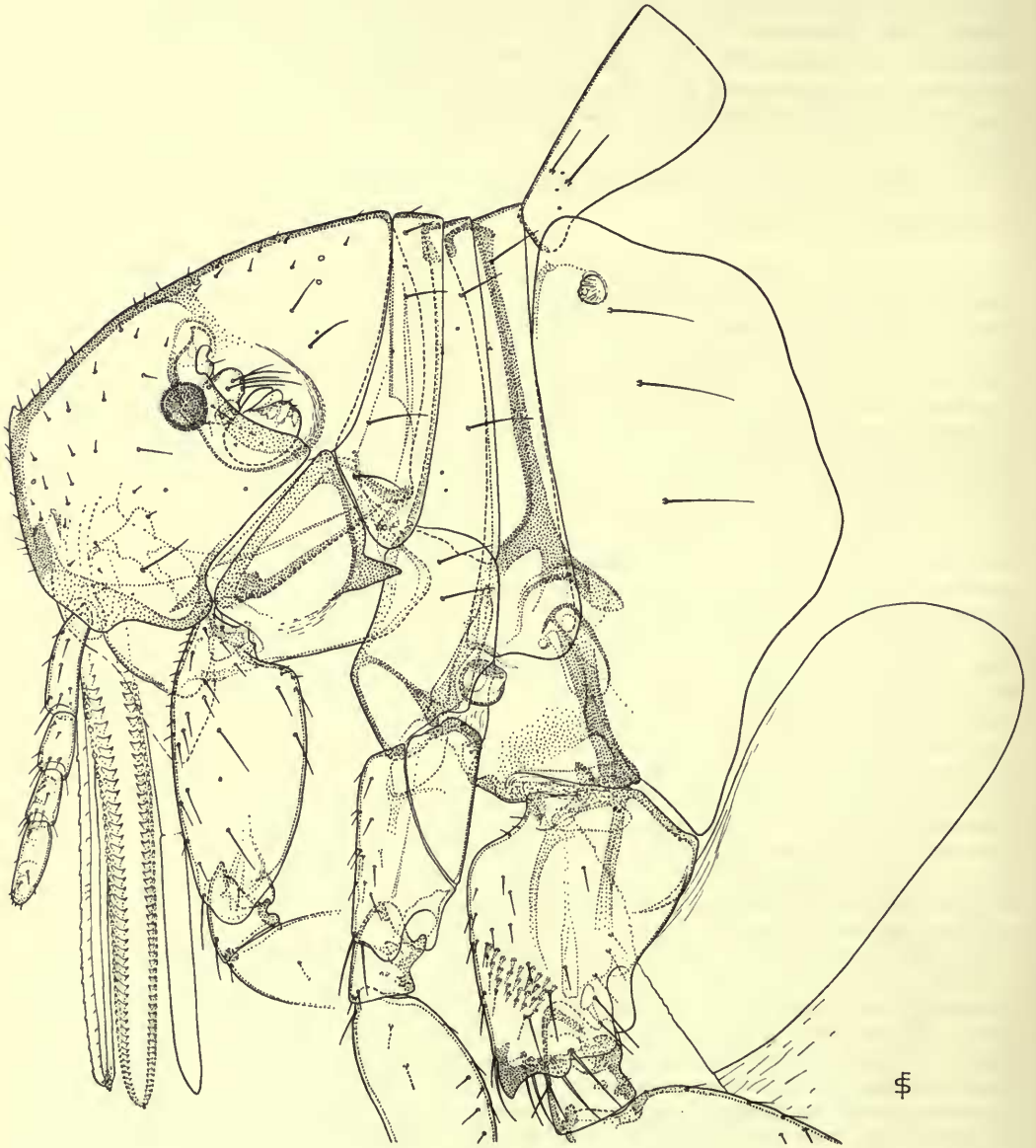
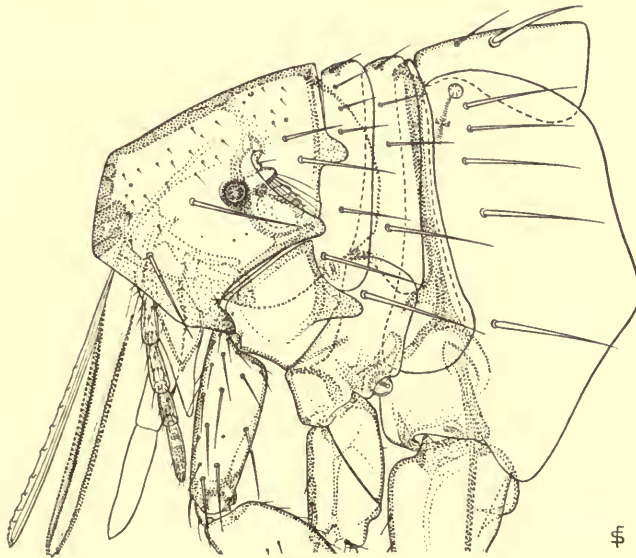


FIG. 3. *Neotunga euloidea* sp. nov. Head, thorax, basal segments of legs, tergum I and sternum II of holotype.

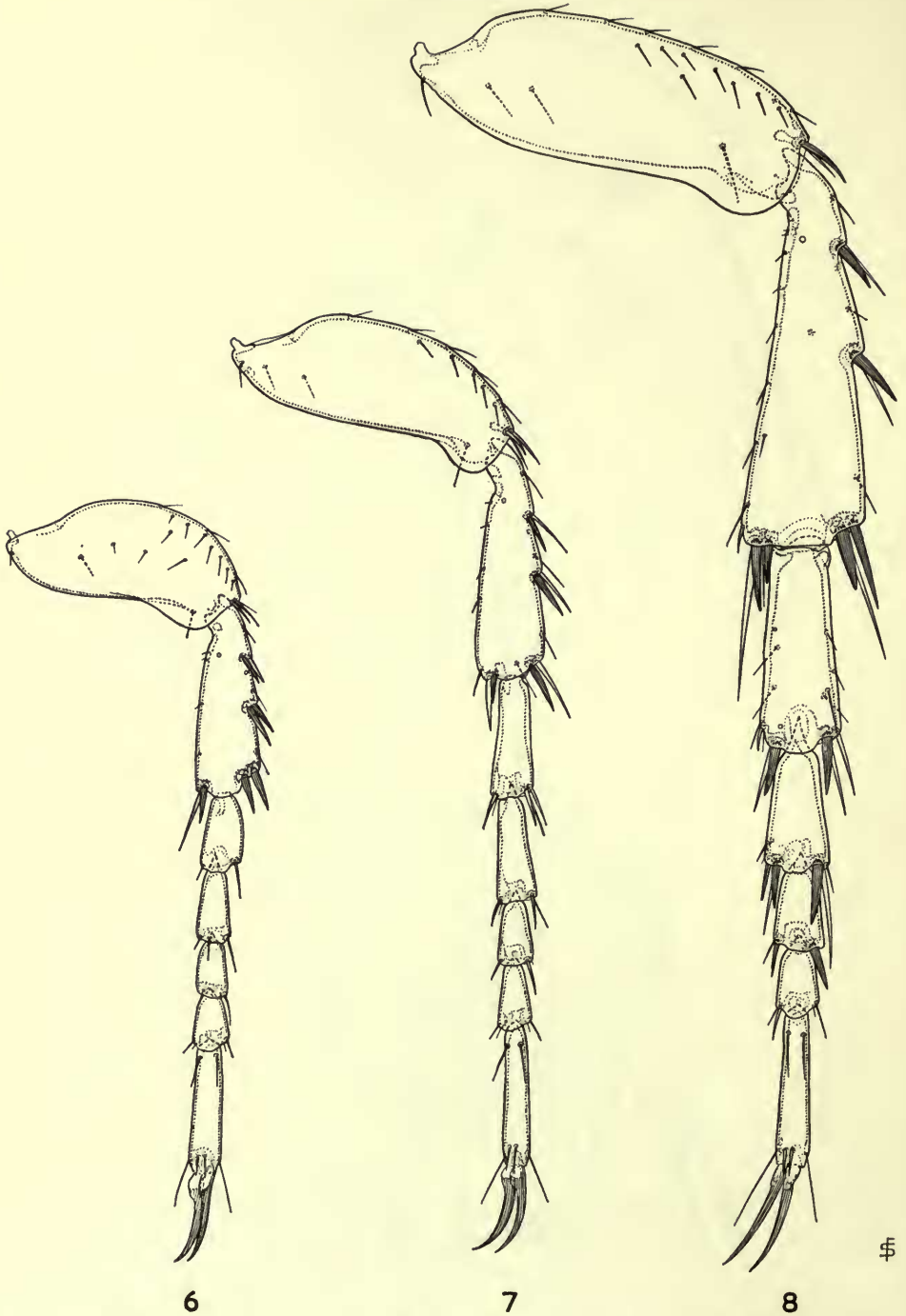


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FIGS. 4-5. Anterior part of females of: 4. *Tunga penetrans* (L.), 5. *Echidnophaga gallinacea* (Westwood).



FIGS. 6-8. *Neotunga euloidea* sp. nov. 6. Fore leg. 7. Mid leg. 8. Hind leg (all of paratypes).

Abdomen (Text-figs. 2, 9-12, 15, 16). Terga I-VII each with a row of two medium-sized setae per side. Spiracular fossae of terga II-VII circular and large, increasing in size from tergum II onwards (the spiracular fossa on the metepimeron is somewhat larger than that of tergum II). Posterior margin of tergum VII dorsally sinuate. Sterna II-VI without setae, sternum VII with two setae near the ventral margin. Tergum VIII with about half a dozen setae on the ventral half and on the inner side with seven or eight strong and straight setae which are placed on a thickening of the wall of the sclerite; no setae above the large and broad spiracular fossa. Lower half of posterior margin of tergum VIII with a small fold. Sternum VIII short and broad, without setae. Sensillum with eight trichobothria each side. Anal tergum with some stout dorsoapical setae below which a number of slender ones. Anal stylet nearly twice as long as broad in the middle with a long apical seta, two preapical ventral setae and two microsetae. Anal sternum short, with about half a dozen slender setae per side.

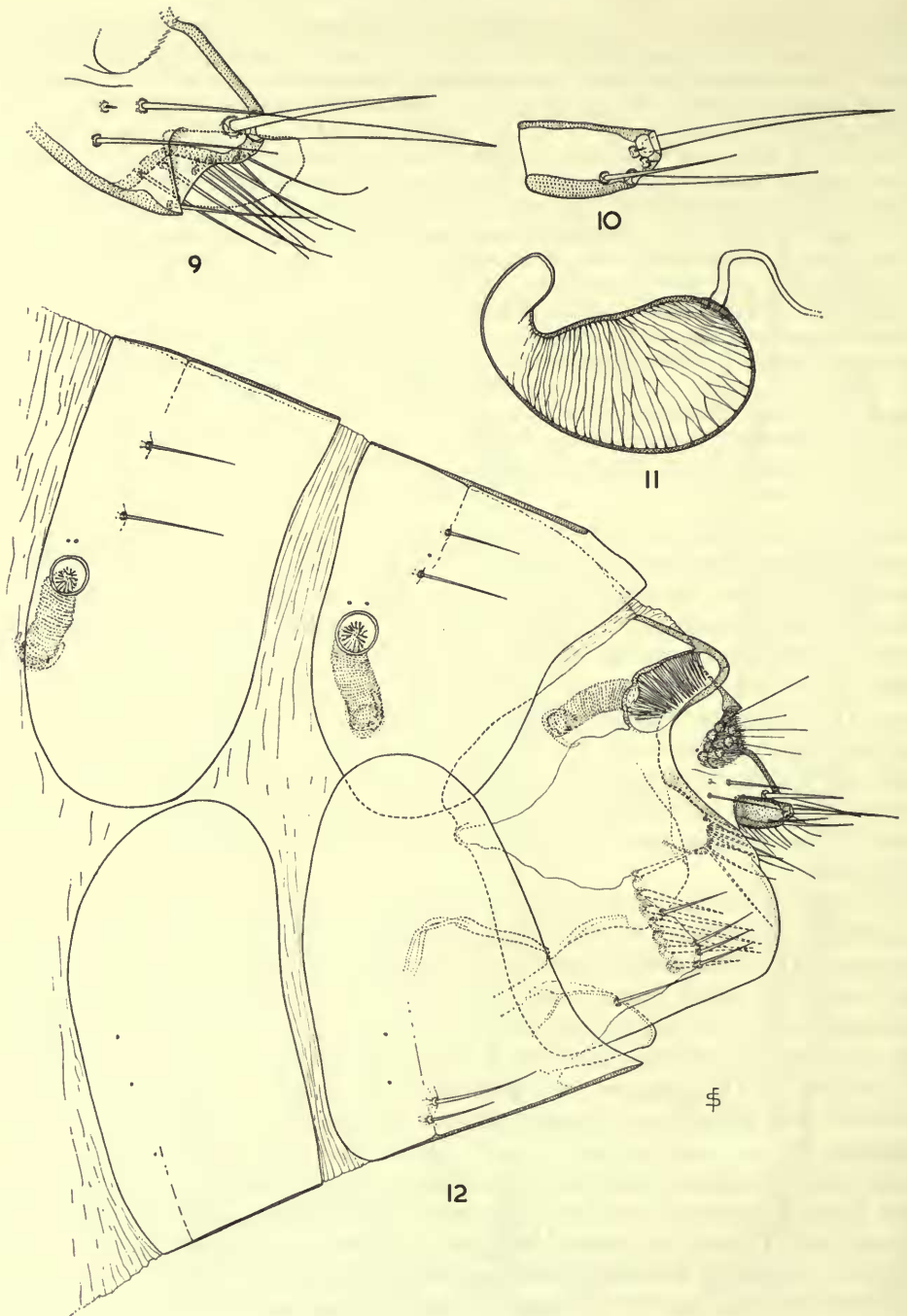
Bursa copulatrix a simple elongate tube; ductus obturatus present. Spermatheca with a rather thinly walled pyriform bulga, which is internally rather coarsely striated, and a rather short and narrow hilla; orifice of spermatheca dorsal. As in other fleas the spermatheca is situated in the right hand side of the abdomen.

Length: Distended females measure from 4 to 7 mm. in length, while the diameter of the abdomen is about 2 mm.; undistended females may be about 1.5 mm. long. Eggs are 0.7-0.8 mm. long, 0.35-0.4 mm. broad.

Embedded females of *Neotunga euloidea* were found in the soft skin, which is almost completely hairless, on all ventral regions of the pangolin *Manis temmincki*; in the pangolin from the Sinoia district there were slight perianal and inguinal concentrations but no such concentrations were observed in the specimen from Que Que. There is a tendency for the nodules containing the engorged fleas to be near the lateral margin of the venter at the edge of the scales; the fleas are not found under the scales. The nodules are not orientated in any particular way and in one instance there were two engorged fleas exactly alongside each other, facing the same direction. Unlike the females of *Tunga*, the embedded flea lies with its elongate body parallel with the skin's surface (Text-fig. 1). Dr. Weir informs me that nodules are often difficult to see and can best be found by examining the skin for lumps, using gentle finger pressure.

The degree of infestation was rather slight in the pangolins examined: 6, 11 and 12 fleas per host individual. Whether heavier infestations occur in nature remains to be discovered. It is interesting to note that the pangolin which was kept alive for two years was, on its death, found to be infested with 11 specimens of *Neotunga euloidea*. This might imply that the flea had been breeding in the cage where the pangolin was kept, for it seems unlikely that these fleas would remain alive and produce eggs for over two years. The pangolin from Que Que showed on the venter a small region of scar tissue with indications of former nodules. As considerable quantities of eggs are produced—the average number of ripe eggs in three specimens was 30—it seems strange that the captive pangolin was not more heavily infested, but the conditions under which it was kept may not have been wholly favourable for the development of the larvae. To keep an infested pangolin in a flea-proof cage would seem the ideal method of eventually obtaining male and unengorged female fleas.

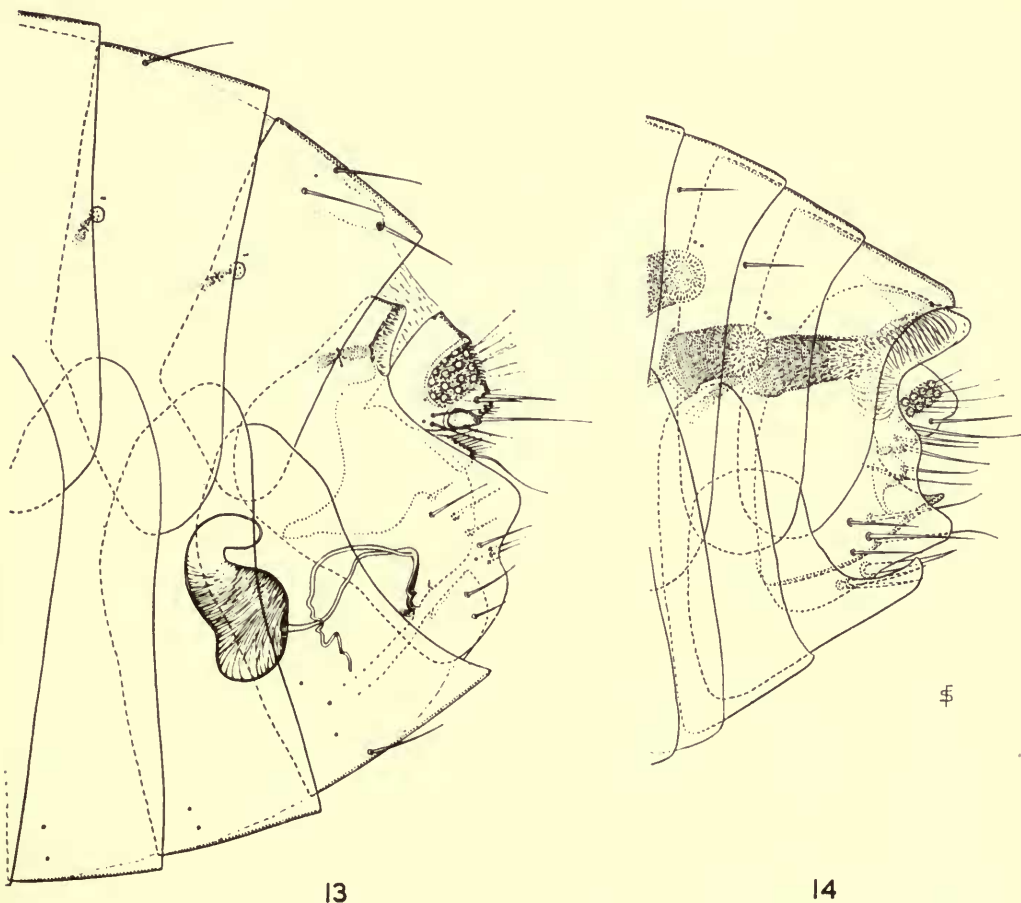
Dr. Weir informed me of two negative records: one adult female *Manis temmincki* collected in December, 1959, in the Melsetter District of Southern Rhodesia (near the border of Mozambique), and one female collected on 19.xi.1960 between Salisbury and Norton.



FIGS. 9-12. *Neotunga euloidea* sp. nov. (paratypes). 9. Anal tergum (stylet in dotted outline). 10. Anal stylet. 11. Spermatheca. 12. Terminal abdominal segments (*i.e.* segments VI-X).

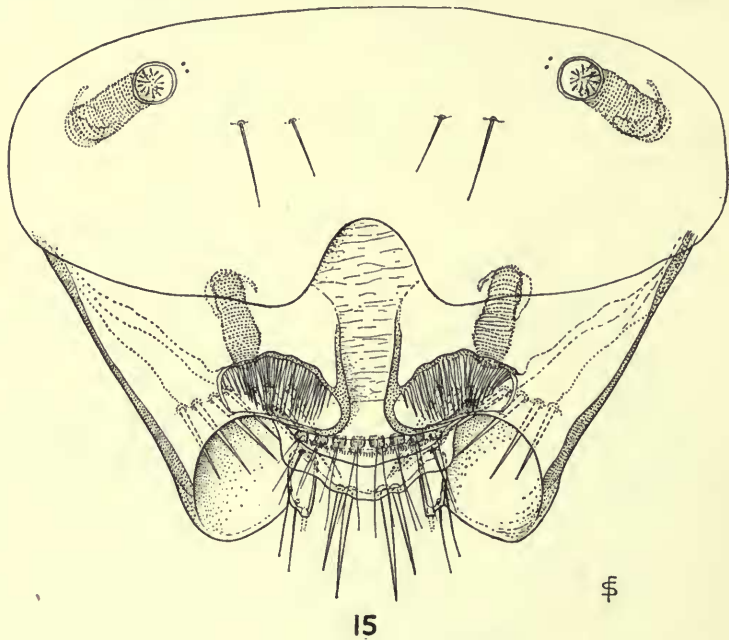
Nearly all fleas were cut out with surrounding skin and flesh and preserved in alcohol. After two or three hours in 10% solution of potassium hydroxide the embedded fleas could be easily removed, with the aid of two minute mounted needles, from the macerated flesh around them, but one has to break the opaque thin silvery "skin" which fits tightly over part of the abdomen.

An astonishing observation was made by Dr. Weir who found that "in some cases the flea seemed to be hanging free from the skin and was only attached by its head." Indeed, among specimens sent by Dr. Weir are a few without surrounding skin or flesh and without the silvery "skin" which is so characteristic of embedded specimens. Such specimens, which had no need to be treated with potash in order to free them, have been used for the photographs reproduced on Pl. I. Mechanically it would seem to be impossible for an engorged specimen to penetrate the skin of the host. It

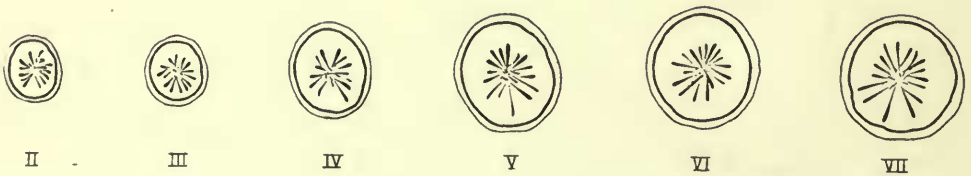


FIGS. 13-14. Terminal abdominal segments of females of: 13. *Echidnophaga gallinaceu* (Westwood). 14. *Tunga penetrans* (L.).

is more likely that these extracutaneous specimens failed to enter the skin and remained attached to it by the strongly developed mouthparts, as for example do females of *Echidnophaga*. If this is indeed the case it is interesting to note that these extracutaneous specimens become engorged to the same extent as embedded ones. This would indicate that engorgement is not correlated with embedding. The opposite appears to be the case in *Tunga*, for Geigy (1953: 41) found that freshly emerged females of *Tunga penetrans*, when removed from the skin after feeding, without giving them a chance to burrow, soon perished without having shown the slightest indications of hypertrophy.



15



16

FIGS. 15-16. *Neotunga euloidea* sp. nov. (Paratypes) 15. Dorsal view of segments VII-X. 16. Spiracular fossae of terga II-VII.

It would seem a considerable disadvantage to the flea not to be able to enter the skin of the pangolin's venter, for the chance may be great that the relatively large and heavy flea, hanging down, will be brushed off since the pangolin has short legs and the venter may sometimes touch the ground. Moreover, the fact that pangolins roll themselves up in a tight spiral when at rest may explain why most of the embedded fleas are found on the sides of the venter, close to the scales, for these sites will very likely be the easiest for the fleas to reach and there they will presumably be least liable to squashing.

Geigy (1953) and Geigy & Suter (1960) have shown that extracutaneous as well as intracutaneous fleas (*Echidnophaga gallinacea* and *Tunga penetrans* respectively were used for their observations) copulate after the female has fixed herself to the host. During and after copulation the female of *Echidnophaga* remains attached to the host by the proboscis, and in the case of *Tunga* the females are embedded in the skin. Since *Neotunga euloidea* is an Echidnophagoid flea with the habits of a Tungoid, one may surmise that here too copulation will take place after the female has entered the skin. The female lying in a plane parallel with that of the surface of the skin, contact between male and female *Neotunga* can presumably be closer than that between the two sexes of *Tunga* and less close than between those of *Echidnophaga*, and the aedeagus of *Neotunga* might therefore be expected to be of a structure intermediate between that of *Echidnophaga* and *Tunga*.

Of special interest are the size and structure of the abdominal spiracular fossae (Text-fig. 16). The metepimeral spiracular fossa is somewhat larger than those of terga II and III which are of subequal size, while that of tergum IV is intermediate between those two and the large ones of terga V-VII. As Jordan has shown (see p. 363 above), in the female *Echidnophaga* the abdominal spiracular fossae are of subequal size and somewhat smaller than the metepimeral fossa, while in female *Tunga* the fossae of terga II-IV are much smaller than the metepimeral one and have actually vanished in *T. penetrans*; however, in this latter genus the fossae of terga V-VIII are greatly enlarged. Jordan postulated the existence of a Tungoid flea in which the anterior abdominal fossae would approach the size of the metepimeral fossa but with those of terga V-VIII enlarged. As can be seen from Text-fig. 16, this is exactly the case in *Neotunga euloidea*. It is tempting to suppose that the differentiation in size of abdominal spiracular fossae in this species followed the apparently fairly recently acquired Tungoid habit of the female to burrow under the skin of the host and is one of several morphological modifications in a basically Echidnophagoid structure pointing towards the great morphological adaptations to be observed in *Tunga*.

In embedded females of *Tunga* the abdominal organs undergo radical changes during the period of hypertrophy. In the hypertrophic females of *Neotunga* similar changes must have taken place, since I found for example the tracheae greatly enlarged and very numerous and of the same structure as in *Tunga*; the midgut, although very long and wide (see Text-fig. 2, in dotted outline), retains its straight shape instead of attaining an S-shape or double S-shape as is the case in *Tunga*, but the relative narrowness of the abdomen in *Neotunga* does not allow a folding of the midgut.

SYSTEMATIC POSITION OF GENUS NEOTUNGA

As has been remarked above, *Neotunga euloidea* is basically an Echinophagoid flea with Tungoid habits. The genus *Neotunga* has in the female sex the following more important characters in common with *Echidnophaga* :

Head (Text-fig. 3, *cf.* Text-fig. 5) :

- (a) frontal margin below the tubercle long ;
- (b) genal seta present, though much reduced ;
- (c) antennal scape and pedicel not set at right angles to the clava ;
- (d) first two claval segments not fused with each other nor with the rest of the clava ;
- (e) an indication of an internal supra-antennal ridge ;
- (f) epipharynx with numerous small projections along anterior margin.

Thorax (Text-fig. 3, *cf.* Text-fig. 5) :

- (g) prosternosome dorsally tapering to a point which is situated opposite to the apex of the antennal clava ;
- (h) prosternosome with a well-developed lateral triangular flange ;
- (i) mesosternal furca long and narrow.

Legs (Text-fig. 3) :

- (j) hind coxa with a patch of small spiniform setae on the lower part of the inner side.

Abdomen (Text-fig. 12, *cf.* Text-fig. 13) :

- (k) tergum VIII without a seta above the spiracular fossa ;
- (l) anal tergum with a pair of well-developed anal stylets.

The following features of female *Neotunga* are characteristic of members of *Tunga* :

Head (Text-fig. 3, *cf.* Text-fig. 4) :

- (a) frontal tubercle pointing upward (in some members of *Echinophaga* a frontal tubercle may be present, but then it is not so well developed as in *N. euloidea*) ;
- (b) microsetae of head pointing upwards ;
- (c) eye somewhat sinuous internally (in some specimens) ;
- (d) claval segments of antenna fused, apart from first two segments ;
- (e) genal lobe much reduced.

Legs (Text-figs. 6-8) :

- (f) tibiae with only two lateral notches bearing stout setae.

Abdomen (Text-fig. 12, cf. Text-fig. 14) :

- (g) spiracular fossae, and their tracheae, of terga V–VIII much enlarged (although smaller than those in *Tunga*) ;
- (h) antesensilial setae absent ;
- (i) genital setae on inner side of tergum VIII much enlarged ;
- (j) sensilium with eight trichobothria each side.

General :

- (k) chaetotaxy much reduced.

In other structural characteristics the genera *Tunga*, *Neotunga* and *Echidnophaga* are much alike, for example all have a strong hook-like tooth at the ventro-anterior angle of the hind coxa which is absent in all other fleas (there is a small tooth in *Delopsylla* but this monotypic genus is very closely akin to *Echidnophaga*).

On the whole the head and thorax and their appendages show a greater affinity to those of *Echidnophaga* than to those of *Tunga*, but the abdomen resembles that of the latter genus more than that of the former. However, the abdominal modifications are a result of adaptation to an ecological niche which is shared only by *Tunga* and they need not necessarily indicate a close phylogenetic relationship. In a system of classification *Neotunga* should be placed somewhere between *Echidnophaga* and *Tunga*, but nearer to the former than to the latter genus.

It is possible that *Neotunga* represents an early step in the evolution from an Echidnophagoid ancestor to a form resembling *Tunga*, and that the ancestors of the extant species of *Tunga* have passed through a stage similar to that exhibited by *Neotunga*.

To put *Echidnophaga* in the same supra-generic group as *Tunga* might seem far-fetched as recent classifications have included these genera in two different subfamilies or even families. However, it should be noted that relationships between groups of species tend to be obscured when members of a certain group take to an ecological niche or a mode of life which is very different from that occupied by members of related groups, and as a result undergo more or less profound morphological changes. Thus the intromittent organ of species of *Tunga* is highly specialized and superficially unlike that of any other flea, but in no other flea is the mode of copulation so extremely unusual. It follows that the genitalia may not be a reliable guide to phylogenetic relationships of fleas which have exchanged the normal ectoparasitic way of life for an endoparasitic one.

The discovery of the male of *Neotunga euloidea* will very likely enable us eventually to assess the true relationships of *Neotunga*, but in compliance with General Recommendation No. 6 of the International Code of Zoological Nomenclature I tentatively place this genus, along with *Echidnophaga* and *Delopsylla*, in the Family Pulicidae.

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